REVISED CRAB MITIGATION STRATEGY AGREEMENT

US Army Corps of Engineers
US Fish and Wildlife Service
Washington Department of Ecology
Washington Department of Fish and Wildlife
Quinault Indian Nation
National Marine Fisheries Service
US Environmental Protection Agency

Grays Harbor Navigation Improvement Project
Grays Harbor, Washington

September 1998

REVISED CRAB MITIGATION STRATEGY AGREEMENT

for the

GRAYS HARBOR CRAB MITIGATION PROGRAM

Grays Harbor Navigation Improvement Project
Grays Harbor, Washington

September 1998

1. INTRODUCTION

The purpose of this Revised Crab Mitigation Strategy Agreement is to establish a long term agreement among the agencies for further implementation of the crab mitigation effort in Grays Harbor (described below). The Grays Harbor Crab Mitigation work group members, representing their respective agencies, developed this revised crab mitigation strategy to document the mutually agreed-to revised procedures to attain the long-term goals initially established for crab mitigation.

The agreement has been prepared, reviewed and accepted by all members of the Grays Harbor Crab Mitigation Work Group. The agencies, by signing this agreement, concur with and accept this revised crab mitigation strategy.

Nothing in this Agreement alters any state or federal law or regulation. This Agreement merely updates the crab mitigation requirements for the Grays Harbor Navigation Improvement Project from those previously described or practiced, in a manner consistent with the National Environmental Protection Act (NEPA).

2. BACKGROUND

Construction of the Grays Harbor Navigation Improvement Project (GHNIP) by the U.S. Army Corps of Engineers was initiated in 1990. The project construction included deepening and widening 23.5 miles of the existing Grays Harbor channel, enlarging existing turning basins, and deepening existing ship berths. The deepened and widened channel (completed except for the last four upstream miles) is now dredged annually to maintain project depths. The Environmental Impact Statement Supplement (EISS) completed in 1989 for this project recognized significant impacts to Dungeness crab. Mitigation measures were implemented to offset losses to the crab resource.

The crab avoidance and mitigation programs, as described in the EISS, were based on several years of research in Grays Harbor. They were, however, not based on actual dredging or full-scale mitigation experience. In the years since project construction, much has transpired: assumptions basic to the original mitigation calculations and costs have proven incorrect, dredging amounts and impacts have varied from those expected, and demand for sediment for beneficial uses (erosion control) has altered maintenance dredging practices. This revised crab mitigation strategy is intended to update the Dungeness crab avoidance and mitigation measures presented in the EISS in order to keep the program relevant to current Corps, sponsor and agency concerns and to protect and perpetuate the crab resources of Grays Harbor.

The revised strategy was developed by a work group that met several times from 1995 to 1998. The work group consisted of agency representatives from the Washington Department of Ecology, Washington Department offish and Wildlife, US Environmental Protection Agency, Quinault Indian Nation, US Fish and Wildlife Service, National Marine Fisheries Service, and the Seattle District Corps of Engineers. The purpose of this work group was to review the Dungeness crab mitigation plan developed for the Grays Harbor Navigation Improvement Project, evaluate crab mitigation efforts to date, and devise a revised strategy that could be used for future mitigation efforts.

3. STRATEGY ELEMENTS

The strategy developed was an attempt to balance the cost of Grays Harbor maintenance dredging and mitigation with the associated risk to the Dungeness crab resource. Maximizing avoidance of crab impacts during maintenance dredging and minimizing oyster shell mitigation to replace lost crabs were major objectives of the strategy. Though new methods of mitigation were considered by the work group, no suitable alternatives were identified. The resulting strategy refines avoidance and mitigation methods used in the past in light of six years of biological monitoring, shell placement and dredging experience.

3.1 Impact Avoidance

These strategy elements address maintenance dredging of the Grays Harbor Channel.

1. *Credit for Dredging Method Avoidance.* In accordance with the 1989 EISS, only crabs lost to maintenance of the widened and deepened portion ("incremental maintenance") of the Grays Harbor Channel are subject to mitigation. Thus, crabs lost during dredging of historic ("non-incremental") maintenance amounts are not replaced. Non-incremental amounts are calculated as the mean number of cubic yards (cy) dredged in a given reach from 1981 to 1989. Any changes in dredging equipment that avoid crab in the incremental portion also avoid large numbers of crabs usually lost to non-incremental maintenance. To this end, it is agreed that all crabs "saved" in the non-incremental yardage by use of a clamshell dredge (instead of a hopper dredge) in Crossover and South Reaches would be credited against past and present maintenance impacts. This credit will thus lower the amount of oyster shell mitigation required for the overall project's incremental impact.

2. *Upstream Clamshell Dredging.* All maintenance dredging from upper Crossover Reach (see Figure 1) upstream will be dredged by clamshell dredge.

3. *Downstream Dredge Timing Avoidance Measures.* Dredging in South and Lower Crossover Reaches may be done by any method from the beginning of the calendar year until 31 May. From 1 June to the end of the calendar year, South and Lower Crossover Reaches will be dredged only by clamshell dredge. Bar and Entrance Channel dredging will also be completed by 31 May. Dredge timing may be reconsidered based on future crab population monitoring.

4. *Minimal Dredging.* Only the minimal amount necessary for navigation needs will be dredged, regardless of government hopper schedules.

5. *Emergency Dredging.* Dredging designated as an emergency by the District Engineer will be considered on a case by case basis, following the Code of Federal Regulations (33 CFR 337.7) approval and coordination procedures. Shell mitigation for impacts caused by emergency dredging will follow the same guidelines as impacts caused by non-emergency dredging.

3.2 Oyster Shell Mitigation

These strategy elements apply to mitigation for past and future impacts, both from GHNIP construction and incremental maintenance.

6. *Mitigation Commitment.* Shell placement will be done for impacts remaining from past dredging, and for any future impacts.

7. *Mitigation Plot Assessment.* The production model produced by the University of Washington (Armstrong *et al.* 1996) will be used to calculate future mitigation production. Young-of-the-year crab will be considered "produced" by the shell plots when they reach approximately 15.5 to 19 mm, or the J4 molt (fourth molt after settlement). The same model and production unit will be used to recalculate all past mitigation production.

3.3 Ongoing Efforts

These elements are needed to promote further avoidance measures, and to keep the crab mitigation effort current.

8. *Continued Excluder Development.* As a possible Corps-wide measure to reduce crab impacts, development of a crab excluder device for hopper dredges will continue until it is either 1) considered adequate for use and deployed in Grays Harbor, or 2) considered to be inadequate for sufficient crab avoidance, and not worthy of further development. A work plan will be provided to the crab working group each year that outlines the specific studies and objectives that will be completed during the year. Credit for successful crab avoidance will be based on field trials and determined by the crab work group.

9. *Crab Population Monitoring.* Trawl surveys for population monitoring of crab abundance began in September 1996 and will take place for at least three years. Population density information will be compared with assumptions made in the Dredge Impact Model (DIM), and may be used to reconsider dredge timing (Element 3). The crab working group will review the monitoring information after three years to decide if additional monitoring is necessary.

10. *Continued Re-evaluation.* The crab working group will continue to meet at least semi-annually to reevaluate and/or refine this strategy. Additions and/or modifications to this agreement may be made by the working group via Strategy Implementation Reports attached to updated project EA's.

4. AGENCY CONCURRENCE AND ACCEPTANCE

The following agency officials agree that this revised crab mitigation strategy documents the mutually agreed to revised procedures to attain the long-term goals initially established for crab mitigation in the Grays Harbor Navigation Improvement Project.

SEATTLE DISTRICT CORPS OF ENGINEERS

25 Sep 98
Date

By James M. Rigsby

Title Seattle District Engineer

WASHINGTON DEPARTMENT OF ECOLOGY

11-22-98
Date

By Tom Fitzsimmons

Title Director

U.S. FISH AND WILDLIFE SERVICE

12/1/98
Date

By Lynn P. Childers

Title Acting Supervisor

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE

11/9/98
Date

By Sara LaBorde

Title Regional Director

AGENCY CONCURRENCE AND ACCEPTANCE, continued

U.S. ENVIRONMENTAL PROTECTION AGENCY

11-19-98 By [signature]

Date

Title EPA

QUINAULT INDIAN NATION

By

Date

Title

NATIONAL MARINE FISHERIES SERVICE

By

Date

Title

PORT OF GRAYS HARBOR

SEPT. 29-98 By [signature]

Date

Title EXECUTIVE DIRECTOR

GRAYS HARBOR CRAB MITIGATION PROGRAM

EVALUATION REPORT

US Army Corps of Engineers
US Fish and Wildlife Service
Washington Department of Ecology
Washington Department of Fish and Wildlife
Quinault Indian Nation
National Marine Fisheries Service
US Environmental Protection Agency

Grays Harbor Navigation Improvement Project
Grays Harbor, Washington

September 1998

1. INTRODUCTION

The US Army Corps of Engineers constructed the Grays Harbor Navigation Improvement Project (GHNIP) in 1990. Project construction included deepening and widening 23.5 miles of the existing Grays Harbor channel (Figure 1), creating larger turning basins and deepening existing ship berths. The Environmental Impact Statement Supplement (EISS) completed in 1989 recognized significant impacts to Dungeness crab *(Cancer magister)* due to hopper and pipeline dredging. It also described a plan for minimizing crab impacts and replacing those crab actually lost.

The crab mitigation program, as described in the EISS, was based on several years of research in Grays Harbor. It was not, however, based on actual dredging or full-scale mitigation experience. In the several years since project construction, much has transpired: assumptions basic to original mitigation calculations have proven incorrect; costs used to justify oyster shell placement have risen significantly; dredging amounts and impacts have varied from those expected; and demand for sediment for beneficial uses has altered maintenance practices. All these factors together contributed to a large deficit in the crab mitigation program, with crab impacts rising higher than expected, and crab replacement falling further and further behind.

To address these disparities, representatives from the Seattle District Corps of Engineers, Washington Department of Ecology, Washington Department of Fish and Wildlife, US Environmental Protection Agency, Quinault Indian Nation, US Fish and Wildlife Service, and the National Marine Fisheries Service convened a Crab Mitigation Work Group to evaluate the mitigation program. The purpose of this work group was to review the Dungeness crab mitigation plan developed for the GHNIP, evaluate crab mitigation efforts to date, and devise a strategy that could be used for future mitigation efforts. This Evaluation Report (ER) and Revised Crab Mitigation Strategy Agreement (RCMSA) are the initial products of this work group. They are intended to update the Dungeness crab avoidance and mitigation measures in light of several years of experience, in order to keep the program relevant to current Corps, sponsor and agency concerns and to protect and perpetuate the crab resources of Grays Harbor.

2. BACKGROUND

2.1 Project Construction

Widening and deepening of the twenty miles of downstream reach, from the ocean bar to Port of Grays Harbor Terminal 4 at Cow Point, was started in April 1990 and completed in February 1991. Over 8 million cubic yards (cy) of sediment were removed. The four miles of upstream reach (from Cow Point upstream to 900 feet above the Weyerhaeuser terminal) have not yet been deepened. Recent charges to the upstream portion of the project have reduced the amount of upstream dredging planned from approximately 2.1 million cubic yards to approximately 52,000 cubic yards. This dredging is presently scheduled for 1999 or 2000, depending on the availability of Federal construction funds. Because Dungeness crab are not regularly found in the upstream reaches of Grays Harbor, no additional crab impacts are expected from construction of the final portion of the project.

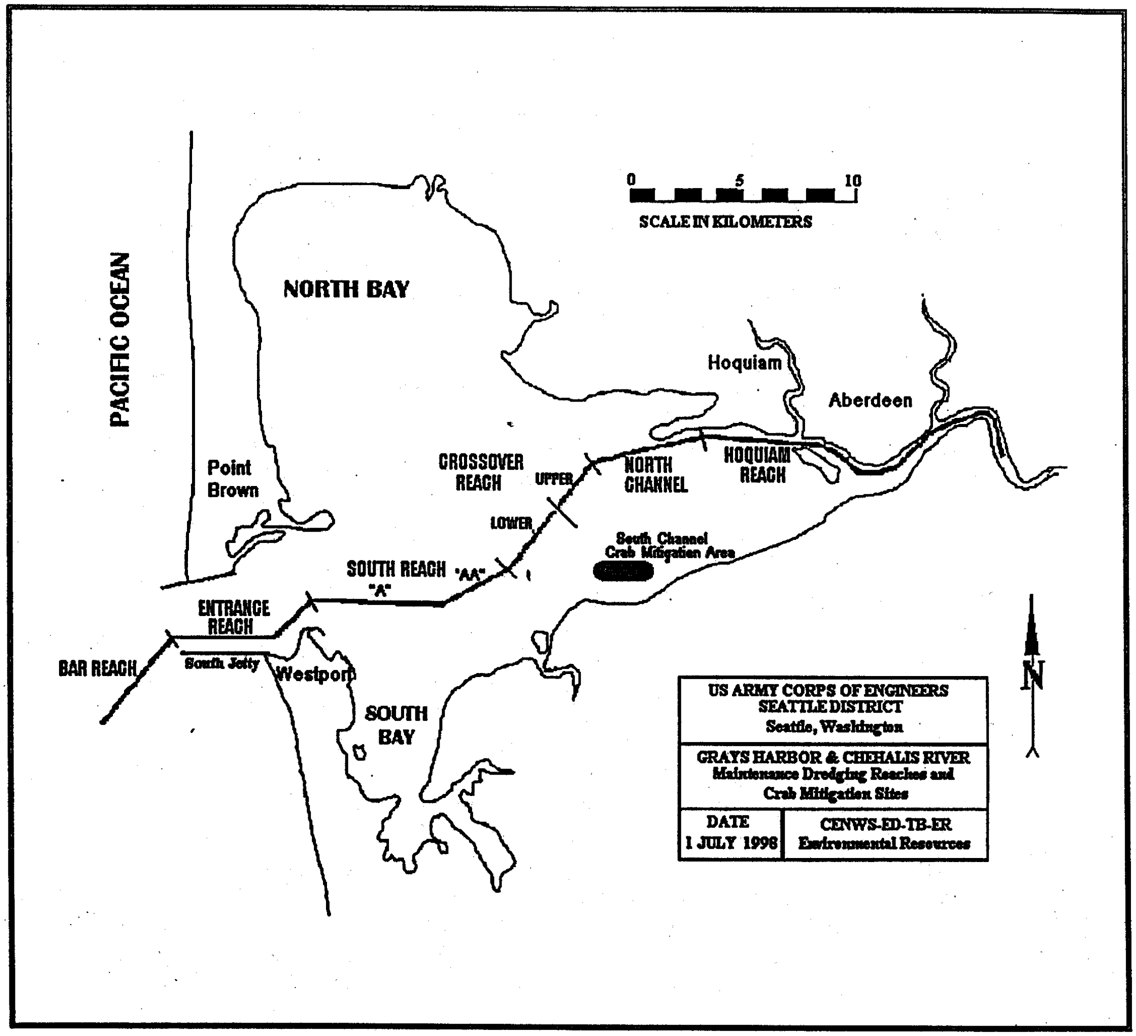

Figure 1. Map of the Grays Harbor Estuary, including dredging reaches and crab mitigation sites.

Mitigation for construction impacts is funded as part of project construction, which is cost-shared with the local sponsor (port of Grays Harbor), and which is assessed and carried out separately from impacts due to project maintenance.

2.2 Project Maintenance

The Grays Harbor Navigation Channel is dredged annually to maintain authorized project depths. The EISS made a distinction between two categories of maintenance dredging: incremental and non-incremental. Non-incremental maintenance dredging is the average yearly volume of sediment dredged from the channel prior to project construction. Incremental Maintenance (IM) is the additional amount of maintenance dredging necessary to maintain the widened and deepened portion of the channel. In the EISS, crab mitigation was required only for IM impacts and not for crabs lost to non-incremental maintenance dredging.

All maintenance dredging, including mitigation for IM crab impacts, is entirely federally funded, and is assessed and carried out separately from impacts due to project construction.

2.3 Crab Impacts

In the years before project construction, a research program conducted by the University of Washington (UW) and Battelle Marine Laboratory investigated Dungeness crab densities and life cycle in the Grays Harbor estuary and nearshore area and the impacts of dredging on crabs. With this data, the UW developed the Dredge Impact Model (DIM) to predict the number of crabs entrained and killed during project construction and maintenance (Armstrong et al. 1987). The DIM incorporates average seasonal crab densities in either upstream or downstream channel reaches with a calculated entrainment rate, natural mortality, and dredge type to estimate the number of crabs lost. During research, crab densities were found to be higher in the outer reaches of the channel (South, Entrance and Bar) than in the inner reaches (Crossover, North Channel, Hoquiam and Cow Point). Also, hopper and pipeline dredges were found to entrain and kill Dungeness crab at a much higher level than did clamshell dredges.

2.4 Crab Mitigation

The Corps addressed the effect of hopper dredging on Dungeness crab by developing both crab avoidance and replacement measures. These measures were presented in the 1989 EISS and included scheduling dredging outside the peaks of high crab abundance and placement of intertidal oyster shell habitat to produce 0+ (i.e. young-of-the-year or YOY) Dungeness crab.

The use of intertidal oyster shell to enhance habitat was based on studies that found higher juvenile crab densities in shell beds than on mudflats (Armstrong et al. 1987, 1988; Doty et al. 1989; Dumbauld and Armstrong 1987; Dumbauld et al. 1993; McGraw et al. 1988). The oyster shell serves as refuge for YOY crab, which settle in late spring and remain in the shell for 2-3 months, then leave the intertidal area for subtidal areas in the estuary or near shore (Armstrong et a1. 1989).

Full scale oyster shell mitigation for Dungeness crab mortalities due to construction dredging began during 1992. Approximately 10,000 cubic yards (cy) of clean oyster shell were spread over 8 hectares (20 acres) of intertidal area in two locations in Grays Harbor that spring. Impacts to crab due to IM dredging began in 1991, and shell plots for IM mitigation have been placed annually from 1994 to 1997. A shell plot for mitigation of additional impacts due to the 1995 Section 111 Beach Nourishment project was placed in 1998. A total of approximately 35 hectares (87 acres) have been placed for these IM crab impacts to date.

3. PROBLEMS

Many aspects of the GHNIP have changed since the 1989 EISS, and many of the original assumptions made about dredging practices and oyster shell mitigation have proved to be erroneous and/or difficult to achieve.

3.1 Dredging Impacts

Construction dredging and crab impacts were approximately what was expected in the EISS. For construction, the DIM predicted that the equivalent number of 2+ crabs lost to dredging would range from approximately 97,000 to 169,000. Actual losses, estimated using crab density data taken monthly during the construction period, were approximately 161,600 age 2+ crabs (Armstrong et al 1991).

Total incremental maintenance dredging amounts have been approximately as they were expected in the EISS, but crab impacts have been much higher (Figure 2.) For IM dredging from 1991 through 1994, the DIM predicted the equivalent loss of 48,000 age 2+ crab. But actual losses to IM dredging from 1991 through 1994 reached almost 162,000 2+ crab (Table 1).

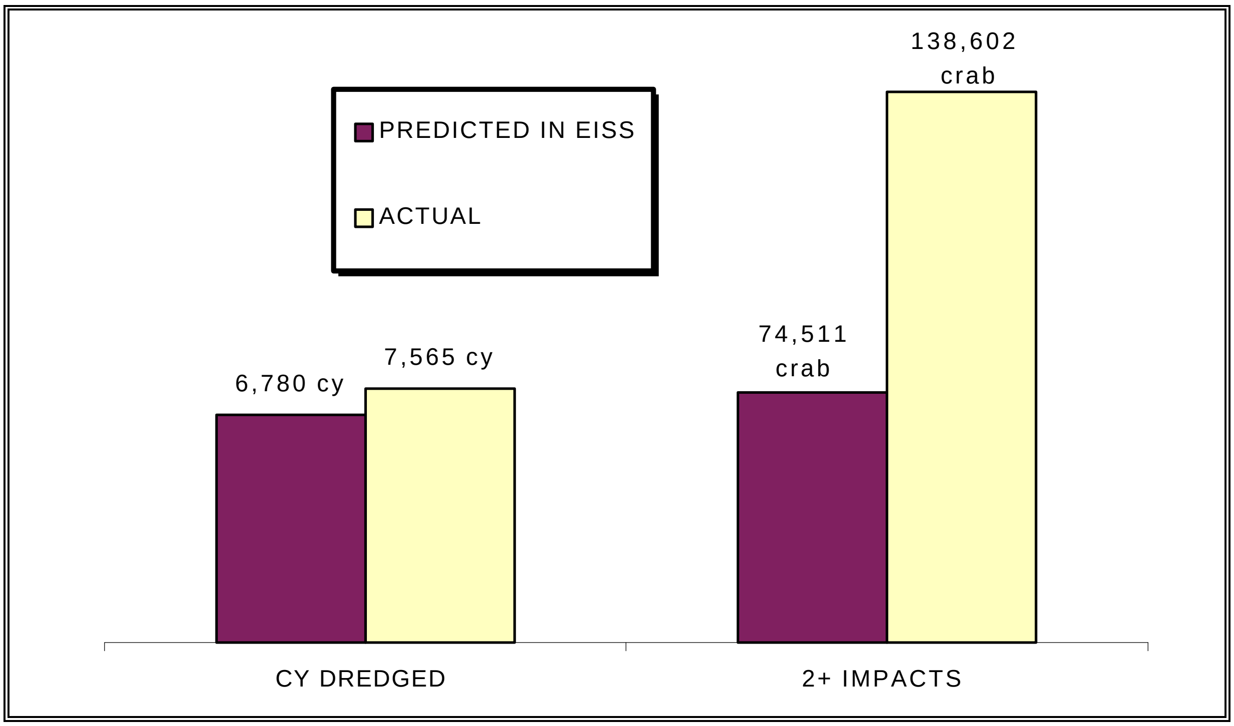

Figure 2. IM dredging impacts, 1991-1997. Although dredging amounts have been only slightly higher, impacts to crabs have been over twice as high as expected in the EISS.

Several factors have contributed to the high number of crab impacts for IM dredging. First, the entrainment rate used in the DIM was changed after the EISS was prepared but before GHNIP dredging began. The entrainment rate, or the ratio of available crabs actually picked up with sediment during dredging, is an important factor in the DIM and significantly affects results (Conquest 1989). It was changed based on collection of additional data and analysis by outside statisticians. Although the entrainment rate was increased only slightly, this change resulted in higher crab impacts per cubic yard dredged than was estimated in the EISS, and these increases have added up over time. Almost 50% of the unexpectedly high impacts can be attributed to this change.

The second major factor contributing to high IM crab impacts is the season in which outer reaches of the Grays Harbor Channel have been dredged. Based on trawl surveys done during the 1980's, crab densities--and thus crab impacts--are much higher during the summer and fall than during the spring in these reaches. In the EISS, it was assumed that all dredging in South, Entrance and Bar Reaches would be completed by the end of May, and this was one of the mitigation measures planned to reduce crab mortalities. In reality, and for many complex reasons, most dredging in those reaches has been actually accomplished during summer and fall months. These seasonal changes account for most of the remainder of the unexpectedly high impacts.

Table 1. Expected and actual IM dredging and crab impacts for maintenance dredging from 1991-1997. Crab impacts are as estimated by the DIM. Negative impacts can occur with credit given for clamshell dredging (Strategy Element 1).

		CY DREDGED (in thousands)		2+ IMPACTS	
YEAR	**PROJECT**	**PREDICTED IN EISS**	**ACTUAL**	**PREDICTED IN EISS**	**ACTUAL**
1991	O&M	1,140	1,106	13,920	41,610
1992	O&M	1,140	1,932	12,644	50,502
1993	O&M	1,140	958	11,369	31,956
1994	O&M	1,140	682	10,098	12,461
1994	Breach fill	0	600	0	24,978
1995	O&M	740	535	8,827	1,776
1995	Beach nour.	0	6	0	436
1996	O&M	740	1,061	8,827	-1,447
1997	O&M	740	685	8,827	1,744
TOTALS		**6,780**	**7,565**	**74,511**	**164,016**

Some of the dredging outside of preferred spring months was due to use of dredged material for erosion protection projects that were not anticipated during planning for the GHNIP. These projects included the South Beach and Half Moon Bay Berms, South Jetty Breach, and Westport Section 111 Beach Fill. In these cases, dredging schedules were driven by requirements of the nearshore and beach fills and not by potential crab impacts. These projects also contributed to higher impacts in other ways: they required more material than would otherwise have been dredged out of the navigation channel, and there were additional impacts due to placement equipment.

In some cases, dredge scheduling may not make much difference in the total number of crabs killed, but it can make a big difference in the amount of mitigation required. For the 1994 breach fill, much of the dredged material was taken out of the South Reach after routine maintenance had already been done for the year. The following year very little maintenance dredging was necessary, and over a two year period the amount dredged was as expected. If the dredging had been done evenly over the two years, the amounts would have all been non-incremental maintenance, and would not have contributed to IM impacts. But by dredging the entire amount in one year, the additional amount was entirely IM dredging, and thus required mitigation.

Other reasons that have contributed to dredging during the periods of high crab abundance include problems with scheduling of the government hopper dredges, which often are used for dredging the outer reaches, and the previous belief that oyster shell placement was efficient enough to increase dredging flexibility over adhering to the timing schedule.

3.2 Shell Supply and Price

In the EISS, the shell purchase and placement cost was assumed to be $12 per cubic yard with a ready shell supply that would provide adequate competition. Since project initiation, shell prices have risen dramatically, and shell plot construction has been much more expensive the originally predicted. Cost for building the shell plots has increased by five to eight times over the predicted cost.

3.3 Shell Retention and Maintenance

The original mitigation plan assumed that the shell plots would retain a useful life of eight years, with slightly declining production each year, and with harrowing once after year three that would recover up to 75 percent of any sunken shell. Monitoring results for the shell plots have shown that much of the shell sinks into the mud within the first season, much faster than predicted by the mitigation plan. In addition, harrowing was found during early trials to be infeasible.

3.4 Crab Production on Shell Plots

Based on initial pilot studies, it was estimated in the EISS that each square meter of shell cover could produce ten 0+ crabs. Studies subsequent to the EISS but prior to the first full scale shell placement suggested that crab densities had been previously under-reported, and that densities of 0+ crabs on test plots were typically between 30 and 100 crabs per square meter (Armstrong et al. 1991). Although crab "production" was not defined in the EISS, the Corps and agencies agreed, based on Armstrong's 1991 study, to assume use by 20 crabs per square meter as the basis for deciding how much shell to place. The monitoring plan agreed to at the time of the first shell placement assumed that the total number of 0+ crab estimated to be on the mitigation sites in August of a given year would be the number of crabs produced.

Crab densities proved to be similar to what Armstrong et al. (1991) had predicted--but only during the first summer following spring placement of the oyster shell (Figure 3). Approximately 90% of all crabs produced have been produced in the first year of shell placement. In following years, not only did most of the shell either sink or become buried, the remaining shell produced much lower densities of 0+ crab. No controlled studies have been done to determine the cause for this decline in production, but observation and circumstantial evidence suggest two main reasons. First, remaining shell is often “silted in,” which may reduce the three dimensional complexity of the oyster shell and thus much of its habitat value. Second, by the year after placement, the shell has often been colonized by the green shore crab

(*Hemigrapsus oregonensis*). These crab inhabit the shell plots year round, and evidence suggests that not only do they compete with juvenile Dungeness for available habitat within the shell plots, but settling Dungeness may actually avoid areas already colonized by shore crab (Visser 1997).

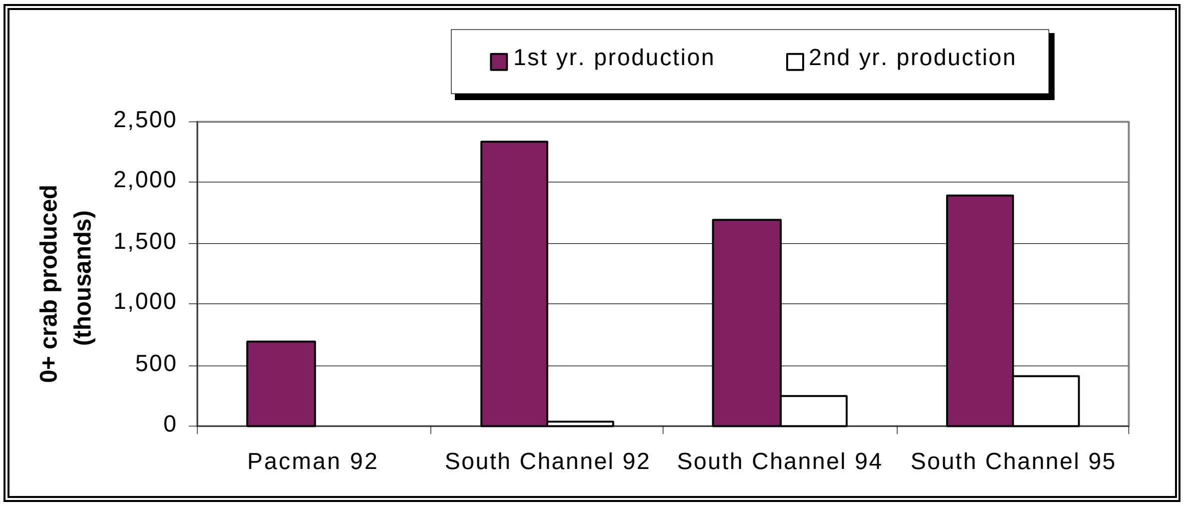

Figure 3. Production of YOY crab drops off dramatically after the shell placement year.

3.5 Land Base Issues

At project conception, it was assumed that each mitigation plot would produce crab for eight years, and then could be covered again with another layer of shell, which again would produce crab for eight years. It was also assumed that suitable land (i.e., mud flats with firm substrate, low ghost shrimp densities, and no eelgrass) would be available for any shell plots needed. With reuse of existing plots, it was initially believed that only 20 hectares of land would be needed for the life of the mitigation program.

But with impacts higher than expected, shell placements only producing crab for one year, and a hesitancy to place new shell on old plots already colonized with shore crabs, the amount of land necessary for shell placement has skyrocketed. By 1995, shell had already been placed on 25 hectares of intertidal land; by 1997 that amount has almost doubled. Because shell sank most rapidly at the North Bay Pacman site, all shell since 1992 has been placed in the vicinity of the South Channel area that was originally identified as suitable. Private ownership of lands to the west of this area preclude additional shell placement there; state lands east and north of the existing area are not easily accessible by placement barges. No other parts of the bay were originally identified as suitable for shell placement. Though there may be strategies to reuse land, or to use land not originally identified as suitable, it is clear that available land may be a limiting factor in future shell placement.

4. STRATEGY SOLUTIONS

The work group was initially formed because it was clear that the crab mitigation program as envisioned in the EISS was not working. The strategy eventually developed by the work group takes into account lessons learned to date in the shell mitigation program and dredging programs. It is an attempt to balance the cost of Grays Harbor maintenance dredging and mitigation with the associated risk to the Dungeness crab resource. Maximizing avoidance of crab impacts during maintenance dredging and minimizing oyster shell mitigation to replace lost crabs were major objectives of the strategy. Though new methods of avoidance and mitigation were considered by the work group, no suitable alternatives were identified. The strategy is based on the following principles:

1. Strategy must address the current mitigation deficit and provide an adequate assurance of minimizing future impacts to Dungeness crab.

2. Strategy must consider problems within the framework of the mitigation agreements in the 1989 EISS. These include assessing impacts with the Dredge Impact Model.

3. Dungeness crabs must be protected to at least the level provided in the 1989 EISS.

4. Economic costs must be considered in the strategy.

5. Strategy must be responsive to new scientific information and technical advances.

The strategy has ten elements that are itemized in the RCMSA. This section documents some of the lessons learned during six years of biological monitoring and shell placement and dredging experience, and describes how the strategy addresses the problems outlined above.

4.1 Dredging Impacts.

4.1.1 <u>Strategy Elements</u>. Because construction dredging impacts are already completed, the strategy elements that address reduction of crab impacts focus on maintenance dredging, as follows.

Element 1. ***Credit for Dredging Method Avoidance***. If a clamshell dredge is used in Crossover or South Reaches, all crabs "saved" in the non-incremental yardage by not using a hopper dredge will be credited against past and present maintenance impacts.

Element 2. ***Upstream Clamshell Dredging***. All maintenance dredging from upper Crossover Reach (see Figure 1) upstream will be dredged by clamshell dredge.

Element 3. ***Downstream Dredge Timing Avoidance Measures***. Dredging in South and Lower Crossover Reached will be done by any method from the beginning of the calendar year until 31 May. From 1 June to the end of the calendar year, South and Lower Crossover Reaches will be dredged only by clamshell dredge. Bar and Entrance Channel dredging will also be completed by 31 May. Dredge timing may be reconsidered based on future crab population monitoring.

Element 4. ***Minimal Dredging***. Only the minimal amount necessary for navigation needs will be dredged, regardless of government hopper schedules.

Element 5. ***Emergency Dredging***. Dredging designated as an emergency by the Corp's District Engineer will be considered on a case by case basis, following the Code of Federal Regulations (33CFR337.7) approval and coordination procedures. Shell mitigation for impacts caused by emergency dredging will follow the same guidelines as impacts caused by non-emergency dredging.

4.1.2. <u>Discussion</u>.

Clamshell Dredging. Of the 3 million cy of maintenance material dredged annually from Grays Harbor, approximately 65 percent is non-incremental maintenance, and is thus not subject to crab mitigation. This portion of the current maintenance dredging has been responsible for two-thirds of the annual crab loss from dredging entrainment, a loss of 8 to 15 thousand adult Dungeness crab in Grays Harbor each year (US Army Corps of Engineers 1989). Hopper dredging in the South, Crossover, and North Channel Reaches caused most of these losses. A clamshell dredge entrains 95 percent fewer crabs than hopper or suction head dredges. It also kills fewer of the crab that it entrains. Depending on crab size, a hopper dredge can kill up to 86 percent of the entrained crabs, while a clamshell dredge kills about 10 percent of the entrained crabs.

Use of a clamshell dredge in the outer reaches of the channel has always been the preferred method of crab impact avoidance. However, clamshell dredging is not safe or feasible in the Bar and Entrance Reaches, where most of the IM impacts occur. Clamshell dredging is the norm for upstream reaches (Cow Point and Hoquiam) because of water quality constraints and cost. But, although clamshell dredging is theoretically feasible in Crossover and South Reaches, hopper dredging is much lower in cost due to the close proximity of the disposal areas. Also, water conditions get increasingly difficult for a clamshell dredge to perform as dredging proceeds towards the more exposed outer harbor. The "credit" concept is an attempt to offset some of the increased costs of downstream clamshell dredging while avoiding more crabs. Credit is expected to reduce but not eliminate the need to replace crabs lost by maintaining the navigation channel.

Reduced Dredging. In the last few years, the amount of dredging needed to maintain project depths in the outer reaches of the Grays Harbor Channel has declined. This is apparently due to the stabilization of the navigation improvement project side slopes and to long term coastal erosion trends, and it is anticipated that needed dredging will continue to decline. This decreased dredging will greatly reduce crab impacts. However, the clean, sandy sediment found in these reaches is in great demand for beneficial use projects--primarily near shore and on shore erosion protection for coastal communities--and in the past there has been political pressure to dredge deeper than is really needed by ship traffic to obtain these sediments. In addition, the Corps operates two hopper dredges, and Seattle District in the past has been obligated to use and pay for these dredges, whether or not the dredging is really needed for the safety of ships using the channel. Thus, Element 4 of the strategy may seem to be unnecessary, but in fact is an important commitment in the face of competing priorities.

4.2 Crab Mitigation.

4.2.1. Strategy Elements. These strategy elements address the replacement of crabs lost to dredging by oyster shell mitigation.

Element 6. ***Mitigation Commitment.*** Shell placement will be done for impacts remaining from past dredging, and for any future impacts.

Element 7. ***Mitigation Plot Assessment****.* The production model produced by the University of Washington (Armstrong *et at.* 1996) will be used to calculate future mitigation production. Young-of-the-year crab will be considered "produced" by the shell plots when they reach 15.5 to 19 mm, or the J4 molt. The same model and production unit will be used to recalculate all past mitigation production.

4.2.2. Discussion.

Commitment. Prior to work group discussions, the Corps requested a re-examination of crab mitigation procedures before doing further shell mitigation, due to the unexpectedly high costs and shell and land limitations. But an analysis done by the University of Washington (Armstrong *et at.* 1996) suggested that counting crabs in August probably has underestimated crab production on the mitigation plots. They developed a model that takes into account multiple crab settlements over one season, and the assumption that crabs leave the intertidal shell plots for subtidal areas when they reach the J4 molt. When crab production was reevaluated with the UW model, it showed that the shell mitigation deficit was smaller than originally calculated. It also showed that shell mitigation for future impacts could potentially be done at a more reasonable price, and with less needed land, than originally believed. With this new understanding, the Corps was able to continue shell mitigation.

Selection of the Production Unit. During negotiations for this strategy, discussions were held to determine a "production unit" or a scientific estimate of what size/age crab were to be considered finished products of the mitigation plots. The "production unit" in this sense was to be the best estimate of the size/age that YOY crabs moved off the plots into subtidal areas. Based on data collected by both the UW and the COE, Armstrong *et al.* (1996) suggested use of either the 13 or 14 molt (the 3rd or 4th molt after YOY crab settle to the substrate). They were unable to select one molt due to discrepancies in data collection methods, and to apparent interannual variations in plot use.

Also relevant to this discussion was the size of crab that was presumed "lost" in the DIM. The group wanted to make sure that crabs replaced equaled crabs lost, at least theoretically. In other words, replacing l00 J4 crabs with 100 J3 crabs would be under mitigating, or vice versa. It was decided that the scientific evidence, as well as personal observations by several members of the group, supported the assumption that most crabs in most years did not leave the intertidal mitigation plots until the 14 molt. This assumption also corresponded with the average size used in the DIM for 0+ lost to dredging.

Production Model*.* The UW model is basically a simple spreadsheet. The only data needed to calculate crab production in a given year is the number of 12 crab (9-12 mm carapace width). With a calculated mortality rate from 12 to 14, the model returns the number of crabs expected to live long enough to leave the mitigation plots. These crabs are assumed to be crabs that would not have survived without the mitigation plots, and that will survive at the same rate as other crab produced in the estuary, and are thus "produced" by the mitigation.

4.3 Ongoing Efforts.

4.3.1. Strategy Elements. These elements are needed to promote further avoidance measures, and to keep the crab mitigation effort current.

Element 8. ***Continued Excluder Development***. Development of a crab excluder device for hopper dredges will continue until it is either 1) considered adequate for use and deployed in Grays Harbor, or 2) considered to be inadequate for sufficient crab avoidance, and not worthy of further development.

Element 9. ***Crab Population Monitoring***. Trawl surveys for population monitoring of crab abundance began in September 1996 and will take place for at least three years. Population density information will be compared with assumptions made in the Dredge Impact Model (DIM), and may be used to modify this model. Resulting information may be used for reconsidering dredge timing (Element 3).

Element 10. ***Continued Re-evaluation***. The crab working group will continue to meet at least bi-annually to reevaluate and/or refine this strategy. Additions and/or modifications to this agreement may be made by the working group via Strategy Implementation Reports attached to updated project EA's.

4.3.2. Discussion.

Excluder. A draghead excluder is a modified draghead on a hopper or suction dredge that acts to exclude Dungeness crab and other marine organisms from being sucked up by the dredge. There has been strong support to develop a Corps-wide draghead design that would successfully reduce or eliminate entrainment of marine animals, and this method of avoidance was favored over other mitigation during initial GHNIP discussions. However, initial designs either did not exclude crabs, or could not withstand dredging conditions.

In recent years, the Corps' Portland District has led the development of the modified draghead. After several years of testing and modifications, a prototype excluder has been field-tested and is currently being refined. Preliminary results from field tests in 1994 and 1995 showed that the excluder may reduce crab entrainment (Shaw 1996). The 1994 data showed a reduction in sandlance and fish. The 1995 data showed that the excluder entrained a lower number of 0+ crab, fish, and shrimp. However, for an excluder to reduce crab impacts by any appreciable amount, it must exclude adult and older juvenile crabs as well as 0+ at a fairly high rate of efficiency. The next stage of excluder development is to construct and test a prototype for the largest government dredge, the *Essayons,* and to continue biological testing on that dredge.

Population Monitoring. During the 1980's, much work was done to investigate the abundance and distribution of Dungeness crab in Grays Harbor and near shore areas (Armstrong et al. 1984,1985, 1986; Dumbauld et al. 1987; Stevens and Armstrong 1984), age class distribution (Armstrong et al. 1985,1986), and seasonal movements (Armstrong et al. 1987). Some of the main conclusions from those studies include:

1. no reproduction takes place in the estuary;
2. females extrude and carry fertilized eggs entirely near shore;
3. eggs hatch and zoeal larvae and most stages of the megalopal larvae develop near shore, not in the estuary;
4. advanced stages of the megalopal larvae enter the estuary from May through June;
5. older crab immigrate into the estuary in early summer;
6. significant populations of several juvenile age classes (0+ from megalopal larvae settlement or 1 + crab immigration) use the estuary for one or two summers of growth;
7. crabs emigrate from the estuary in late summer through fall as relatively large juveniles approaching sexual maturity (> 1 +); and
8. crab larvae settle and develop to sexual maturity near shore.

This work established that the Grays Harbor estuary is used by Dungeness crab as a nursery habitat, and that crabs move between the estuary and near shore areas at different life stages. Little is known about when crabs move into and out of the estuary, whether the navigation channel acts as a corridor to concentrate crab during this movement, or if the crab move at certain times based on physical or biological factors. These studies also made it apparent that dredging during seasons of low abundance greatly reduces crab loss.

However, these studies included very few trawls from the Bar Channel, and none at all from the Entrance Channel. For the DIM, South Reach data were averaged with the limited Bar data to estimate densities in all three outer reaches. But these three reaches all have quite different habitat characteristics, and may be used quite differently by crab. Further efforts to assess crab abundance; and movements in these areas will allow hopper dredging to be scheduled more accurately at times when crab impacts could be minimized or avoided, and to make any necessary adjustments to the DIM.

For this element, crab population data is being collected for the Bar, Entrance and South Reaches for at least three years. The purpose of the monitoring is to determine the seasonal abundance of crab (0+, 1+, >1+) in these reaches more accurately throughout the year and over time. Trawls are conducted monthly except when weather and/or safety conditions prevent them. At least four trawls are taken in each reach (South, Entrance and Bar) each month; trawls are split evenly (to the extent possible) between high and low slack tides. Data from the first 2 years of population monitoring is presently being analyzed, and any adjustments found necessary will be made to the trawl program. After three years, data will again be analyzed and decisions about whether further trawl studies are necessary, and if or how to modify dredge schedules, will made by the work group

Continued Re-evaluation. Many factors contribute to the need to make this strategy dynamic. While much is known about crab abundance, distribution, and movement in Grays Harbor, our knowledge is still far from complete. Some examples of project uncertainty that may contribute to changes in this agreement include:

- The DIM has some parameters based on professional judgment and others with large confidence intervals.
- The estuary is dynamic and may be undergoing changes that could affect Dungeness crab distribution, abundance, and biology.
- Shell prices or other placement prices could change, making mitigation measures more or less expensive.

This element proposes to make the strategy dynamic by considering and adjusting the strategy concepts over time. Issues will be discussed during biennial meetings. Any clarifications, additions, changes, or amendments will be documented via special report, and attached to an updated Environmental Assessment (EA). These reports may be prepared by any member of the work group, although each must be signed by all signatory agencies before taking effect.

5. CALCULATIONS

Many assumptions and details have gone into the calculations that form the basis for this agreement. In this section, those will be detailed to the extent possible so that all methods are available for public and agency scrutiny, and so that future calculations can remain consistent.

5.1 Dredging Impacts

The DIM assesses the number of crab of different age groups lost to dredging, and normalizes these losses to the number of 2+ crab lost. Input includes the number of cubic yards dredged, the reach dredged, and the method of dredging. Other components that are frequently modified are crab densities (when real time data is available) and mortality assumptions (when disposal is other than in open-water sites).

To calculate impacts, only incremental maintenance amounts dredged are entered into the DIM. Non-incremental maintenance amounts have been calculated by taking the average maintenance amount dredged, by reach, from 1981-1989. Incremental maintenance is the amount dredged over these thresholds, by reach, in any given year.

Because dredging can overlap seasons, a decision must be made about which season the "incremental" portion of the dredging was accomplished. In all calculations to date, incremental dredging has been spread proportionally across seasons. For example, assume 650,000 cy were dredged from Cow Point in a given year, with half dredged in winter (January-March) and half dredged in spring (April-May). The non-incremental amount allowed in Cow Point is 374,000 cy; the remaining 276,000 cy is the incremental portion and must be mitigated for. In this case, half of the incremental portion (138,000 cy) will be assigned to the winter, and half to the summer.

Dredging credits are also calculated using the DIM. The total amounts dredged by clamshell (in Crossover and South Reaches only) are entered in the model as if the dredging was actually done by hopper. Dredging is assumed to have taken place in the actual season dredged. For example, if 250,000 cy are dredged by clamshell in South Reach in July, no losses are tallied because none of the dredging was incremental maintenance. But the 250,000 cy is entered in the DIM as if this amount was dredged by hopper in the summer, and the resulting 2+ impacts are subtracted from the total impacts. When the volume dredged in a particular reach is less than its non-incremental volume, then the actual dredge volume is used to calculate the credit. When the dredge volume is greater than the non-incremental volume then the maximum non-incremental volume is used to decide the credit. Dredging credits are then subtracted from dredging impacts.

5.2 Crab Mitigation

The goal of crab mitigation is to return an equivalent number of crab to the crab fishery as were lost to it. These "replacement crabs" are not returned to the fishery in the same year they were lost to it.

To determine the amount of oyster shell habitat required for mitigation, the following steps are followed:

1. The number of YOY crab needed to replace the adults lost to the fishery is determined by dividing adults lost by 0.017, which is the estimated natural survival from settlement to winter of the 2+ year (Armstrong *et al.* 1987).
2. The number of juveniles needed is divided by the average production to get the number of square meters of shell cover needed to produce them.
3. The resulting number of square meters is divided by the number of years of shell plot life. For 1992 and 1994 placements the life of a shell plot was assumed to be 8 years; that assumption has been reduced to one year.
4. Result is amount of area needed for oyster shell mitigation.

6. IMPLEMENTATION PLAN

The RCMSA has been implemented according to the attached plan since the beginning of Fiscal Year (FY) 1997. Status and methods are detailed below.

6.1 Construction

Although no more impacts are expected due to construction dredging, there is still a deficit of crabs killed during initial construction that have yet to be replaced with mitigation. It was estimated that approximately 9.5 million 0+ crabs would be needed to replace all crabs lost to construction. Shell was placed in 1992 to mitigate for those impacts at two sites (Pacman and South Channel) but, through fall of 1997, only about 3.65 million 0+ crabs have been produced at those sites (Table 2).

Settlement of juveniles on the shell plots varies greatly from year to year, due to a multitude of environmental factors that are difficult to predict. Since oyster shell mitigation began, production of J4 0+ has ranged from 6 crabs m^{-2} in 1997 to 65 crabs m^{-2} in 1991. On the 1992 construction mitigation plots, production was approximately 31 crabs m^{-2} on the Pacman site and 40 crabs m^{-2} on the South Channel site. But production has been much lower in recent years on the IM mitigation plots, leading to caution about assuming that a specific amount of production will occur in any specific time frame.

Table 2. Status of construction deficits and mitigation.

0+ Impacts	0+ Produced	0+Remaining to Mitigate	Approx. ha needed (32 crabs m-2)	Approx. ha Needed (19.5 crabs m-2)
9,503,588	3,646,900	5,856,688	18.3	30.0

Because construction accounts need to be finalized within the next few years, it was necessary to determine an "endpoint" for construction mitigation prior to actual implementation, assuring that impacts are adequately mitigated while defining an end to the Corps' obligation. To this end, an initial plan and contingency plan were formulated. The Corps will initially place 20 hectares of shell over a 2-year period, which will produce the balance of crab mitigation if average crab production (32 crabs m^{-2}) or better occurs. If there is less than average crab production during the two years, shell placement on up to an additional. 10 hectares in the third year will complete the required crab mitigation, irrespective of total production. This contingency plans assumes that average crab production over the three years will be (19.5 crabs m^{-2}). Though production could conceivably fall below this target, the work group agreed that this 50% level of contingency was a reasonable compromise, and that further shell placement beyond 30 hectares would not be required. If there is higher than average crab production during the initial two years, the required mitigation will be met as soon as the necessary crab production is achieved. If more crabs are produced by this placement than are needed to eliminate the construction deficit then the "surplus" will be credited to the IM deficit. The Corps reserves the right to adjust annual placement amounts based on shell availability and other variables within the 20-30 hectare placement discussed above. This effort will complete all crab mitigation requirement for GHNIP construction.

Final crab mitigation will begin in the spring of the fiscal year in which federal construction funds become available (most likely 2000), will be accomplished with one contract, and will take up to three years to complete. After this period, the construction accounts will be closed, and no additional funding will be required for further shell mitigation or monitoring for construction impacts.

6.2 Incremental Maintenance.

6.2.1 Dredging. A two year contract for maintenance dredging was let in 1997 that requires the contractor to abide by all timing and dredging plant restrictions. All future contracts and/or agreements will also require performance in accordance with strategy agreements and objectives.

6.2.2 Mitigation. Estimated future O&M mitigation requirements are much less than in the past for three main reasons: 1) reduction in anticipated maintenance dredging in the outer reaches due to coastal erosion, 2) credit for the clamshell dredging, and 3) the UW formula for measuring mitigation success. Table 3 summarizes all maintenance dredging data collected through 1997, and projects maintenance dredging mitigation requirements until the end of the 50 year project life.

Table 3. Status of IM deficits and mitigation through 1997.

Impact Year	0+ Impacts	0+ Produced	0+ Remaining to Mitigate	Approx. ha needed (32 crabs m^{-2})
1991-1997 (actual)	9,648,000	6,086,472	3,561,528	11.1
1998-2040 (estimated)	4,023,899	0	4,023,899	12.6
Total 1991-2040	13,671,899	6,086,472	7,585,427	23.7

At a rate of approximately 10 hectares per year, IM mitigation will require another three years of shell placement. However, these placement estimates are for planning purposes only and should not be interpreted as the mitigation commitment. As always, the remaining mitigation commitment will be based on the accumulated crab impacts and the number of crab actually produced by the shell plots. Placement years will be coordinated with the work group.

6.2.3. Excluder Testing. Field testing done in 1994 and 1995 was aboard the Corps dredge *Yaquina*, the smaller of 11 the two west coast Corps dredges. But most nearshore dredging, where the majority of IM impacts occur, is done by the larger dredge *Essayons.* Since 1995, a larger prototype of the excluder was built, along with a sampling device for the deck of the *Essayons.* However, planned field sampling in 1996 and 1997 was not accomplished, because the *Essayons* was used in areas of low crab abundance. Sampling has again been scheduled for 1998 on the *Essayons*, and sampling will focus on taking enough samples to test the exclusion of older crabs.

6.2.4. Population Trawling. Monthly trawling samples in the South Reach, Entrance and Bar Channels began in September 1996, and will continue through September 1999. Data collected to date are presently being analyzed, to assure that the sampling design is appropriate for the questions asked, and to identify any early trends.

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GRAYS HARBOR CRAB MITIGATION PROGRAM

ENVIRONMENTAL ASSESSMENT

Grays Harbor Navigation Improvement Project
Grays Harbor, Washington

September 1998

1. INTRODUCTION

The 1989 Final Environmental Impact Statement Supplement (EISS) for the Grays Harbor Navigation Improvement Project (GHNIP), is hereby incorporated by reference. That document described the placement of oyster shell for juvenile Dungeness crab *(Cancer magister)* habitat as mitigation for crab impacts due to channel dredging. It also described some methods for avoiding crab impacts during dredging. Environmental Assessments (EAs) addressing plans and coordination specific to each full scale shell placement were prepared in 1992, 1994, 1995, 1996 and 1997, and those are incorporated by reference. EAs addressing maintenance dredging plans specific to each year have been prepared annually through 1997, and those are also incorporated by reference.

Since 1995, an interagency work group has met to evaluate and update the crab mitigation program. This EA evaluates modifications made by this group to the crab mitigation program, and includes the workgroup's resulting Evaluation Report and Crab Strategy Agreement. All references are available at the Seattle District office for inspection and use in connection with this EA.

2. AUTHORITY

The original Grays Harbor navigation channel was authorized by Congress in the Rivers and Harbors Act of 3 June 1896. Planning studies for the Grays Harbor Navigation Channel Improvement Project were initiated under resolutions dated 21 October and 30 December 1957, of the U.S. Senate Committee on Public Works, and under resolution by the House of I Representatives' Committee on public Works on 16 July 1958. The final feasibility report and environmental impact statement (EIS) was completed in September 1982 and approved in May 1985 by the Chief of Engineers, with minor changes in the recommended plan. The Grays Harbor Navigation Improvement Project was authorized by Congress on 17 November 1986 in Section 202 of the Water Resources Development Act of 1986 (public Law 99-662). The Record of Decision for the final EIS was signed on 18 March 1987. The final General Design Memorandum (DGM) and EIS Supplement (EISS) was approved on 31 March 1989. Copies of the authorizing documents are on file at the Seattle District office.

3. PROPOSED ACTION

The proposed action is as described in the Revised Crab Mitigation Strategy Agreement (RCMSA) attached to this EA, and is intended to mitigate for crab impacts caused by construction and maintenance dredging of the widened and deepened portion of the Federal Navigation Channel. The RCMSA describes methods to avoid and minimize crab impacts during future maintenance dredging. It also describes how crabs not yet replaced for past construction and maintenance dredging impacts, and crabs unavoidably lost to future maintenance dredging, will be replaced. None of the actions described in the RCMSA are new to of the Grays Harbor mitigation program. The RCMSA merely refines methods used in the past in light of six years of biological monitoring, shell placement and dredging experience.

4. ENVIRONMENTAL CONSEQUENCES OF PROPOSED ACTION

The RCMSA reduces both crab impacts and oyster shell placement below previous levels, thus reducing environmental impacts of both dredging and mitigation. Environmental consequences of dredging and placing oyster shell on mud are as stated in previous environmental documentation. No impacts to threatened or endangered species will result from the oyster shell placement.

5. COORDINATION

The entire crab mitigation program was reviewed by a group of agency scientists from the Corps, Washington Department of Fish and Wildlife (WDFW), U.S. Fish and Wildlife Service (USFWS), Washington Department of Ecology (Ecology), the Quinault Indian Nation (Quinault), the Environmental Protection Agency (EPA) and the National Marine Fisheries Service (NMFS). This Crab Mitigation Working Group met several times from 1995 to 1998 to review dredging impacts and crab production on the mitigation plots, to determine whether the plan as drafted in the EISS was still the desired method of mitigation. The resulting RCMSA and Evaluation Report describe future impact avoidance and mitigation requirements consistent with the evolution of the project.